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Two New Species of *Carex* sect. *Capitellatae* (Cyperaceae) from Japan

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Carex ruralis J. Oda & Nagam. and *C. koyaensis* J. Oda & Nagam. (sect. *Capitellatae*) are described from Japan as new to science. These species are similar to *C. capillacea* Boott, but *C. ruralis* is distinct from *C. capillacea* in having fewer (4-8) pistillate flowers, leaves narrower (0.5-0.8 mm wide) and involute to trigonous, and perigynia lacking glandular dots. *Carex koyaensis* is distinct from *C. capillacea* in having rhizomes long creeping, culms shorter (10-20 cm long), leaves recurved, and perigynia weakly nerved and without glandular dots. Both species are also distinct from *C. capillacea* in the achene micromorphology. The cellulose anticlinal walls of *C. capillacea* are exserted beyond the silica deposits, while those of *C. ruralis* and *C. koyaensis* are entirely covered by the silica deposits. The satellite bodies of *Carex ruralis* and *C. koyaensis* are smaller and fewer than those of *C. capillacea*. Moreover *C. koyaensis* often has a honeycombed anticlinal wall. A key to the Japanese species of *Carex* sect. *Capitellatae* is provided.

Key words: achene morphology, *Carex, Carex* sect. *Capitellatae*, Cyperaceae, Japan, new species

Carex sect. *Capitellatae* Meinsh. is one of the unispicate groups in the genus and is characterized by the densely flowered ovoid spikes, ovoid perigynia, and somewhat soft culms and leaves (Meinshausen 1901). This section is diverse in eastern Asia, and has been treated as a section comprising about six species and three varieties (Kükenthal 1909). In Japan six species and one variety have been recognized since Ohwi (1936), but *C. semihyalofructa* Tak. Shimizu was recently added to this section (Shimizu 2005).

In section *Capitellatae*, *Carex capillacea* Boott has the widest distribution, extending to the Kuriles in the east, Sakhalin to the north, the Himalaya to the west and to New Zealand to the south (Egorova 1999). This species is distinguished from other species of sect. *Capitellatae* by smooth culms, spikes 5-10 mm long, and perigynia yellowish green, distinctly nerved and 2.5-4 mm long (Ohwi 1936). The two new species proposed in this paper are both clearly related to *C. capillacea*, sharing characteristics such as the smooth culms and irregularly trigonous to tetragonous, pistillate scales with obtuse apex, and ovoid perigynia with distinct nerves.

Materials and Methods

We examined specimens of *Carex* sect. *Capitellatae* deposited in HYO, KPM, KYO, OSA and SHO.

The longest culm on each herbarium sheet was measured using a ruler. Leaf width was determined at the widest part of the widest leaf on each herbarium sheet using a light microscope. The

TABLE 1. Gross morphology and achene micromorphology of *Carex ruralis*, *C. koyaensis* and *C. capillacea*

taxon	locality	voucher specimen	culm length (cm)	leaf width (mm)	number of pistillate flowers	glandular dots on perigynia	number of satellite bodies mean±SD	platform	standing anticlinal wall not covered by platform
C. ruralis									
	Tsukude-mura, Aichi Pref.	*K. Torii s.n.* (KYO)	30	0.5	4	absent	0.13±0.4	concave	absent
	Dandoyama, Aichi Pref.	*K. Torii 606* (KYO)	30	0.8	4	absent	2.7±3.8	concave	absent
	Hosokute, Mizunami-shi, Gifu Pref.	*G. Murata et al. 327* (KYO)	48	0.5	4	absent	0.13±0.4	concave	absent
	Kakishita, Kani-shi, Gifu Pref.	*G. Murata & S. Tsugaru 23593* (KYO)	28	0.8	6	absent	0.07±0.3	concave	absent
	Nakatsugawa-shi, Gifu Pref.	*S. Tsugaru et al. 27714* (KYO)	30	0.7	5	absent	0.73±0.9	concave	absent
	Reizan, Ayama-gun, Mie Pref.	*J. Oda 140* (KYO)	27	0.6	5	absent	7.3±5.0	concave	absent
	Marubashira, Ayama-gun, Mie Pref.	*Y. Tsutsui s.n.* (KYO)	26	0.5	5	absent	17.3±3.4	concave	absent
	Nagata, Igaueno-shi, Mie Pref.	*K. Yamawaki s.n.* (KYO)	25	0.6	5	absent	12.7±1.8	concave	absent
	Tanokami-yama, Shiga Pref.	*J. Oda & A. Tominaga 1300* (KYO)	25	0.6	4	absent	8.4±2.9	concave	absent
	Ninniku-sen, Nara-shi, Nara Pref.	*K. Seto 12297* (OSA)	21	0.5	5	absent	0.93±1.3	concave	absent
	Hoshida Enchi, Katano-shi, Osaka Pref.	*S. Amano 4455* (KYO)	31	0.5	4	absent	2.9±2.6	concave	absent
	Kurondo Enchi, Katano-shi, Osaka Pref.	*S. Amamo 1841* (KYO)	25	0.7	4	absent	5.9±4.5	concave	absent
	Yamada-cho, Kobe-shi, Hyogo Pref.	*Tak. Shimizu 81423* (KYO)	25	0.5	4	absent	0.60±0.9	concave	absent
	Mt. Rokko, Kobe-shi, Hyogo Pref.	*G. Murata 7167* (KYO)	20	0.5	5	absent	7.4±4.5	concave	absent
	Hatta-cho, Kobe-shi, Hyogo Pref.	*N. Fukuoka & N Kurosaki 4475* (KYO)	33	0.7	4	absent	3.6±2.6	concave	absent
			28.3±6.5[a]	0.61±0.12[a]	4.5±0.7[a]		4.7[b]		
C. koyaensis									
	Koya-san, Wakayama Pref.	*J. Oda 1639 & S. Yamamoto* (KYO)	20	1.5	5	absent	5.9±2.7	slightly concave	absent
	Gozaisho-dake, Mie Pref.	*J. Oda 1657* (KYO)	15	1.7	4	absent	8.2±2.9	slightly concave	absent
	Kuroko-rindo, Tsuruga-shi, Fukui Pref.	*K. Kada 85066* (KYO)	14	1.5	6	absent	3.7±2.8	slightly concave	absent
	Ohno-cho, Saeki-gun, Hiroshima Pref.	*T. Sato s.n.* (KYO)	11	1.2	4	absent	2.2±1.7	concave	absent
			15.0±3.7[a]	1.5±0.21[a]	4.8±0.96[a]		5.0[b]		
C. capillacea									
	Shikotan, Hokkaido	*J. Ohwi 247* (KYO)	35	1.5	9	present	16.2±2.4	slightly concave	present
	Utonai, Tomakomai-shi, Hokkaido	*Tak. Shimizu 83479* (KYO)	40	1.0	11	present	15.6±2.4	slightly concave	present
	Kuzakai, Shimohei-gun, Iwate Pref.	*J. Oda 928* (KYO)	25	1.5	11	absent	20.1±1.9	slightly concave	present
	Myoko-kogen, Niigata Pref.	*J. Oda 882* (KYO)	35	1.6	11	present	18.9±3.2	slightly concave	present
	Karuizawa, Nagano Pref.	*Tak. Shimizu 81453* (KYO)	35	1.8	12	present	16.5±4.2	concave	present
	Miyagawa, Chino-shi, Nagano Pref.	*Y. Hayashi s.n.* (KYO)	29	2.3	13	present	16.9±3.1	concave	present
	Nenoue-kogen, Nakatsugawa-shi, Gifu Pref.	*N. Fukuoka & N. Kurosaki 9784* (HYO)	30	2.0	10	present	14.4±1.8	slightly concave	present
	Ryogaike, Inabe-gun, Mie Pref.	*J. Oda 587* (KYO)	30	1.5	11	present	15.7±3.3	slightly concave	present
	Hatomine shitsugen, Shiga Pref.	*J. Oda & M. Ichikawa 1437* (KYO)	31	1.2	8	present	14.2±2.9	slightly concave	present
	Hiruzen, Maniwa-gun, Okayama Pref.	*G. Murata 12452* (KYO)	26	1.1	8	present	18.3±2.9	slightly concave	present
	Ebino-shi, Miyazaki Pref.	*Tak. Shimizu 86257* (KYO)	18	0.8	11	present	16.3±2.6	slightly concave	present
	Bhainsi Kharka, E. Nepal	*N. Kurosaki et al. 8820449* (HYO)	10	0.7	8	absent	13.4±2.0	slightly concave	present
	Mt. Kinabalu, Sabah, Malasia	*J. M. B. Smith 465* (KYO)	35	1.3	13	present	17.6±3.3	slightly concave	present
			29.2±8.1[a]	1.41±0.46[a]	10.4±1.8[a]		16.5[b]		

a: mean ± SD, b: mean

number of pistillate flowers per spike was counted from the inflorescence with the most flowers on each herbarium sheet; the result was corrected by adding the number of scars of fallen pistillate flowers.

For leaf anatomy, living materials obtained in the field or cultivated in the garden in Kashiba-shi, Nara Pref. were used. Leaves were cut at the middle of the blade using a razor blade and cross sections were observed with a light microscope and illustrated.

For micromorphology of the achene epidermis, achenes were removed from the dissected perigynia and soaked for 3 or 6–10 hrs in acetolysis solution (concentrated sulfuric acid : acetic anhydride 1 : 9 v/v), then rinsed in acetic acid for 10 min, and placed in a bath type ultrasonic cleaner for 30 min with 70% ethanol to remove the cuticle and outer periclinal walls of the epidermis. Three hr soak was employed for observation of the outer periclinal wall or cellulose anticlinal wall as redidue of dissolution. After air-drying, the achenes were sputter-coated with platinum using a JEOL JFC-1600 Auto Fine Coater, and examined using a JEOL JSM-6060 scanning electron microscope. The materials were selected by considering their geographical distribution. Voucher specimens are kept in KYO, SHO and OSA (Table 1). The number of satellite bodies was counted from 12–15 cells in the middle part of the achene surface of each sample (Table 1). Terminology follows Rettig (1990), Egorova (1999) and Liu & Lin (1999).

Results and discussion

Carex ruralis J. Oda & Nagam., **sp. nov.** (Figs. 1, 5B–D, 6, Table 1)

Species nova affinis *Carici capillaceae* Boott, sed foliis angustioribus, spicis paucifloris, et utriculis sine glandulis differt.

Typus. Japan, Shiga Pref., Otsu-shi, foot of Mt. Tanokami-yama, alt. 350 m, 24 May 2003, *J. Oda & A. Tominaga* 1300 (holo- KYO; iso- KPM, OSA, TI).

Perennial herbs. *Rhizomes* abbreviated. *Culms* filiform, irregularly trigonous to tetragonous, often grooved when dry, smooth, 20–30 (–48) cm long, 0.4–0.6 mm in diam. *Leaves* shorter than culms at anthesis, as tall as culms later; outer leaves involute to trigonous, 0.5–0.8 mm wide; inner leaves trigonous, 0.4–0.7 mm wide; basal sheaths light brown. *Spike* solitary, terminal, ovate, 4–6 mm long, upper part staminate 2–3-flowered, lower part pistillate 4–6 (–8)-flowered. *Staminate scales* narrowly ovate, apex obtuse, rusty brown, caducous, 1.5–1.8 mm long. *Stamens* 3. *Pistillate scales* ovate, apex obtuse, rusty brown, caducous, 1.3–1.6 mm long; lowermost scale often shortly aristate. *Perigynia* ovoid, trigonous, gradually tapering to short beak slightly bidentate, 2.2–2.8 mm long, 1.1–1.3 mm wide; nerves distinct on adaxial surface but inconspicuous on abaxial surface; glandular dots absent. *Stigmas* 3. *Achenes* ovoid, trigonous, tightly wrapped by perigynium, light brown, dark brown at maturity, 1.3–1.6 mm long. Epidermal cells with silica central body and truncate apex; small satellite bodies 0–10 (–17), on concave platform, with slightly undulate anticlinal walls. Anticlinal walls entirely covered with silica deposit.

Japanese name. Satoyama-harisuge (nov.)

Distribution. Japan, endemic: Honshu (Gifu, Aichi, Mie, Shiga, Kyoto, Osaka, Hyogo and Nara Prefs.) (Fig. 6)

Habitat. Poor marshy soils, often with *Pinus densiflora*; at lower elevations of hills and mountains.

Other specimens examined. Gifu Pref.: Hosokute, Hiyoshi-cho, Mizunami-shi, alt. 400 m, 17 V 1975, *G. Murata et al. 327* (KYO); Nenoue-kogen, Ena-shi, alt. 850 m, 2 VI 1996, *S. Tsugaru et al. 23560* (KYO, OSA); along a small stream, Kakishita, Kani-shi, alt. 150 m, 2 VI 1996, *G. Murata & S. Tsugaru 23593* (KYO); Funagado, Matsukura-cho, Takayama-shi, alt. 890 m, 20 V 1989, *H. Nagase 89285* (KYO); Tajimi-cho, Toki-shi, 10 IV 1930, *K. Shiota 37* (KYO). —Aichi Pref.: Tsukude-mura, Prov. Mikawa, alt. 450 m, 30 V 1954, *G. Murata 7334* (KYO);

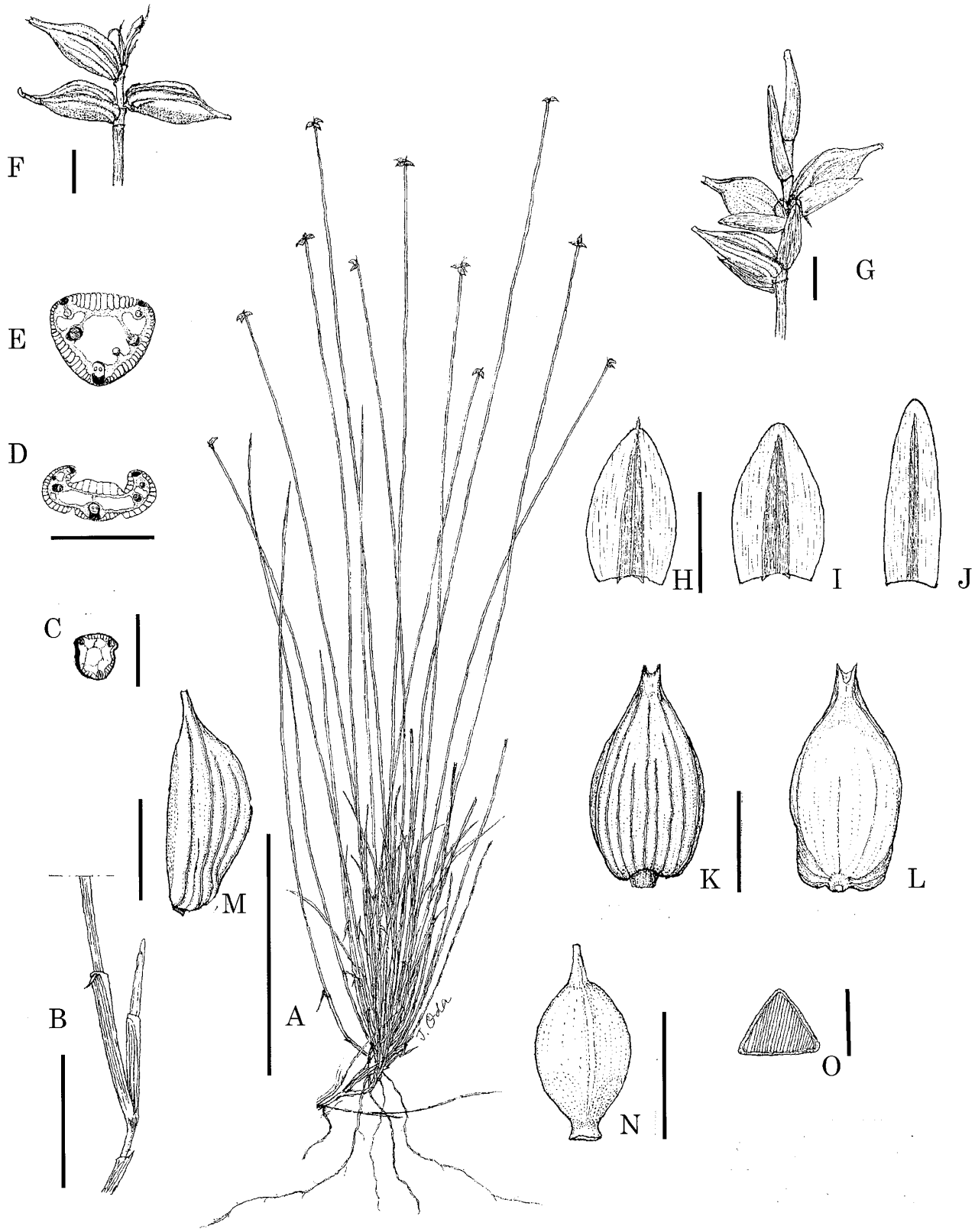

FIG. 1. *Carex ruralis* J. Oda & Nagam. A: habit. B: basal sheath. C: culm, cross section. D: outer leaf blade, cross section. E: inner leaf blade, cross section. F: spike, scales fallen. G: spike. H: lowermost pistillate scale. I: pistillate scale. J: staminate scale. K: perigynium, adaxial view. L: perigynium, abaxial view. M: perigynium, lateral view. N: achene, adaxial view. O: achene, cross section. Bar = 5 cm for A; 1 cm for B; 0.5 mm for C–E; 1 mm for F–M. [foot of Tanokami-yama, Shiga Pref., *J. Oda & A. Tominaga 1300* (KYO)]

Uratani, Mt. Dandoyama, Prov. Mikawa, 5 VI 1948, *K. Torii 606* (KYO); Iwanami, Tsukude-mura, Minamishitara-gun, 30 V 1955, *K. Torii s.n.* (KYO); Kamogatani, Tsukude-mura, Minamishitara-gun, 30 V 1955, *K. Torii s.n.* (KYO); Kitayama-marsh, Okazaki-shi, alt. 150 m, *N. Kurosaki 24582* (SHO). —Mie Pref.: Marubashira, Prov. Iga, Ayama-gun, 14 V 1961, *Y. Tsutsui s.n.* (KYO); Nagata, Ueno-shi, 9 V 1999, *K. Yamawaki s.n.* (KYO); Aoyamahane, Iga-shi, alt. 300 m, *A. Tominaga s.n.* (KYO). —Shiga Pref.: Okuyama, Minamitani, Uedakami-mura, Kurita-gun, 24 V 1921, *Z. Tashiro s.n.** (KYO); Kitakomatsu to Kurotani, via Otsu-shi, alt. 600 m, 29 V 1983, *G. Murata 44846* (KYO); Tashiroguchi, Mt. Tanokami-yama, alt. 300 m, 31 V 1986, *M. Kuwashima 36236* (OSA); Sugiyama, Shigaraki-cho, alt. 345 m, 30 IV 1998, *K. Seto 48918* (OSA). —Kyoto Pref.: Ruri-kei, Nishihonme-mura, Funai-gun, 18 V 1930, *G. Koidzumi s.n.**(KYO); Uji, Prov. Yamashiro, V 1926, *I. Tomonaga s.n.** (KYO); Komon-jinja, Ohhara-mura, Prov. Yamashiro, 15 V 1931, *M. Tagawa 354* (KYO); Chono-yama to Daidoji, Ujitahara-cho, Tsuzuki-gun, 5 V 1953, *M. Hutoh 9002* (OSA); Yufune Shinrin-koen, Wazuka-cho, Soraku-gun, alt. 280 m, 2 VI 2002, *S. Tsugaru et al. 32984* (KYO). —Osaka Pref.: Mt. Kenbi, Nishinose-mura, Toyono-gun, 3 V 1960, *M. Hiroe 13663* (KYO); Mt. Kenbisan to Yamabe, Nose-cho, Toyono-gun, alt. 520 m, 6 V 1985, *G. Murata 45383* (KYO); Kurondo-enchi, Katanoshi, 7 V 1994, *S. Amano 1841* (KYO); Hoshida-enchi, Katano-shi, alt. ca. 230 m, 13 V 2001, *S. Amano 4455* (KYO). —Hyogo Pref.: Mt. Nagao-yama to Mukogawa, Kirihata, Takarazuka-shi, alt. 300 m, 19 V 1995, *N. Fukuoka et al. 8903, 8904* (HYO, KYO, OSA, SHO); Amagodani, near Najio, Nishinomiya-shi, alt. 300 m, 5 VI 1971, *K. Seto 19291* (OSA); Mt. Rokko, alt. 800 m, 5 VI 1954, *G. Murata 7167* (KYO); Mt. Rokko, in Settsu, 1 VI 1952, *M. Togashi 485* (KYO); Rokosan-cho, Nada-ku, Kobe-shi, alt. 770 m, 15 V 1993, *T. Kobayashi 22792* (SHO); near Tanigami, Arima-gun, 12 V 1935, *Z. Yoshino 747* (KYO); Moshi, Sanda-shi, 30 V 1985, *T. Kobayashi 2842* (HYO, SHO); Hatta-cho, Kitaku, Kobe-shi, alt. 300 m, 16 V 1985, *N. Fukuoka & N. Kurosaki 4474, 4475* (KYO); Nakayama to Tenpo-ike, Ogo-cho, Kita-ku, Kobe-shi, alt. 300 m, 3 VI 1979, *N. Fukuoka & N. Kurosaki 2469* (SHO); Tanigami, Yamada-cho, Kita-ku, Kobe-shi, alt. 450 m, 8 V 1994, *S. Miyake 2928* (SHO); Harano, Kita-ku, Kobe-shi, 27 V 1981, *Tak. Shimizu 81423* (SHO); Mt. Nadareo-san, Kita-ku, Kobe-shi, alt. 450 m, 21 V 1994, *T. Kobayashi 25684* (HYO, SHO); Iwatani-toge, Yamada-cho, Kobe-shi, 29 V 1977, *S. Hosomi 17490* (HYO, KYO); Kamaya-Shinden, Imada-cho, Taki-gun, 24 V 1969, *S. Hosomi 8411* (HYO); Mt. Saikoji-yama, Nakahata-cho, Nishiwaki-shi, 11 V 1997, *T. Kobayashi 30388* (SHO); Mt. Kasagata-yama, Yachiyo-cho, Taka-gun, 26 V 1985, *T. Kobayashi 2774* (HYO, SHO); top of Mt. Kasagata-yama to Neuno, 15 V 1983, *Tak. Shimizu 83255* (KYO). —Nara Pref.: near Ninnikusen, E of Nara, Nara-shi, alt. 400 m, 9 VI 1963, *K. Seto 12297* (OSA); Tawaraguchi-cho, Ikoma-shi alt. 350 m, *J. Oda 1731* (KYO).

*Specimens cited by Ohwi (1936) as *C. capillacea*.

Carex koyaensis J. Oda & Nagam., **sp. nov.** (Figs. 2, 4A, 5E–F, 6, Table 1)

Species nova affinis *Carici capillaceae* Boott, sed rhizomatibus longe repentibus, culmis brevioribus, foliis molliusculis et recurvatis, spicis paucifloris, et utriculis leviter nervatis sine glandulis differt.

Typus. Top of Mt. Koya-san, Ito-gun, Wakayama Pref., Japan, alt. 830 m, 20 May 2006, *J. Oda & S. Yamamoto 1639* (holo- KYO; iso- KPM, OSA, TI, TNS).

Perennial herbs. *Rhizomes* long creeping. *Culms* filiform, trigonous or irregularly tetragonous, smooth, 10–20 cm long, 0.4–0.6 mm in diam. *Leaves* shorter than culms at anthesis, as long as culms later; outer leaves V-shaped, 1.2–1.8 (–2) mm wide; inner leaves triquetrous, 0.8–1.2 mm wide; basal sheaths light brown. *Spike* solitary, terminate, ovoid, 4–6 mm long; upper part staminate, 2–3-flowered; lower part pistillate, 4–6 (–8)-flowered. *Staminate scales* narrowly ovate, apex obtuse, rusty brown, caducous, 1.5–1.8 mm long. *Stamens* 3. *Pistillate scales* ovate, apex obtuse, rusty brown, caducous, 1.3–1.6 mm long; lowermost scale often shortly aristate. *Perigynia* ovoid to widely ovoid, trigonous, gradually tapering to short beak, beak faintly bidentate, 2–2.3 mm long, 1.1–1.3 mm wide; nerves moderately distinct on adaxial surface, inconspicuous on abaxial surface; glandular dots absent. *Stigmas* 3. *Achenes* ovoid, trigonous, rather loosely enclosed by perigynium, light brown, dark brown at maturity, 1.2–1.5 mm long. Anticlinal walls of epidermis entirely covered by silica deposits. Epidermal cells

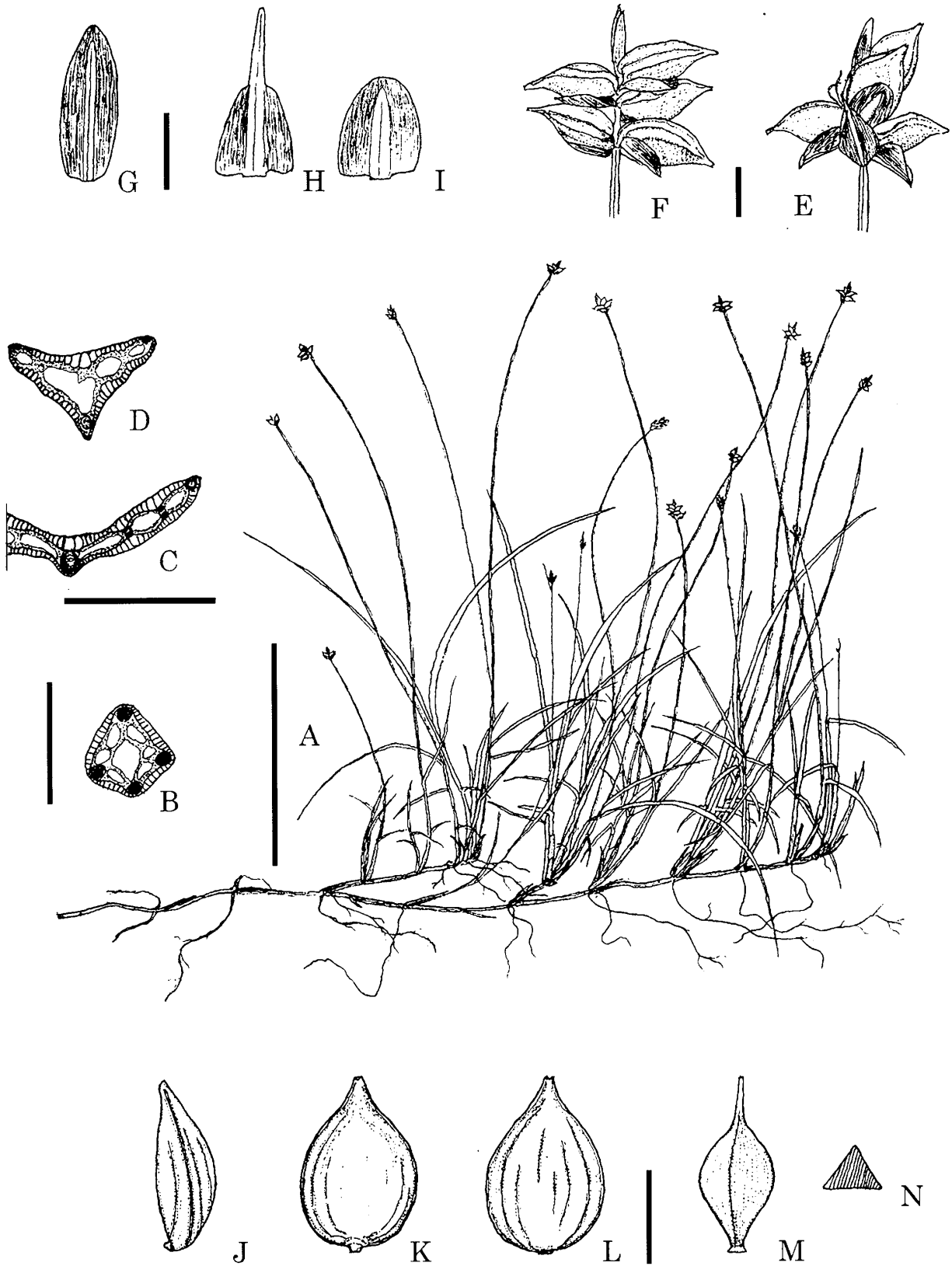

FIG. 2. *Carex koyaensis* J. Oda & Nagam. A: habit. B: culm, cross section. C: outer leaf blade, cross section. D: inner leaf blade, cross section. E & F: spike. G: staminate scale. H: lowermost pistillate scale. I: pistillate scale. J: perigynium, lateral view. K: perigynium, abaxial view. L: perigynium, adaxial view. M: achene N: achene, cross section. Bar = 5 cm for A; 0.5 mm for B–D; 1 mm for E–M. [top of Koya-san, Wakayama Pref., *J. Oda & S. Yamamoto 1639* (KYO)]

with central silica body and 2-8 inconspicuous satellite bodies on concave platform. Anticlinal silica walls often honeycombed.

Japanese name. Koya-harisuge (nov.)

Distribution. Japan, endemic. Central and western Honshu (Fukui, Mie, Shiga, Hyogo, Wakayama, Hiroshima, Tottori and Yamaguchi Prefs.) (Fig. 6)

Habitat. Wet places by streamlets, not submerged; transitional between warm and cool temperate zone in mountains.

Notes. Plants reported as '?*Carex onoei*' by Katsuyama (1994) from Yamaguchi Pref. are *Carex koyaensis* (see specimens examined below).

Other specimens examined. Fukui Pref.: Kurokorindo, Tsuruga-shi, 10 VI 2002, *K. Kada 85064* (KYO). —Mie Pref.: Mt. Gozaisho, Aotaki to Kunimi path, Komono-cho, Mie-gun, 25 VII 1962, *N. Fukuoka 4926* (KYO); near the top of Mt. Gozaisho-dake, Suzuka-shi, alt. 1150 m, *J. Oda 1657* (KYO). —Shiga Pref.: Shiratani to Mt. Mikuni-yama, Nishinosho-mura, Takashima-gun, 11 V 1922, *G. Koidzumi s.n.** (KYO). —Hyogo Pref.: Moshi, Sanda-shi, 10 VIII 1977, *S. Hosomi 17724* (KYO). —Tottori Pref.: Ashizu, Chizu-cho, Yazu-gun, 17 V 1972, *A. Tanaka 12554* (KYO). —Hiroshima Pref.: Ohno-mura, Saeki-gun, 30 V 1932, *T. Sato s.n.* (KYO). —Yamaguchi Pref.: Sasagahara, Akeragi-mura, Abu-gun, *K. Oka 18429***, *18431*** (KPM).

* Specimen cited by Ohwi (1936) as *C. capillacea*.

** Specimens cited by Katsuyama (1994) as ?*Carex onoei*.

Leaves

The shape of the leaves of the three species differ from each other. *Carex ruralis* differs from the other two species in leaf cross section. The outer leaves of *C. ruralis* are involute (Fig. 1D) to trigonous and the inner leaves are trigonous (Fig. 1E), both inner and outer leaves are less than 1 mm wide (Table 1). Most of the outer leaves of *C. capillacea* and *C. koyaensis* are V-shaped in cross section and 0.8-2 mm wide (Figs. 2C, 3C); the inner leaves are triquetrous (Figs. 2D, 3D). When the leaves of *C. capillacea* are less than 1 mm wide, the length of the culm is less than 20 cm, suggesting that these plants are growing under poor conditions (Table 1).

The cross sections of the leaves of *C. koyaensis* and *C. capillacea* are similar. The leaves of the vegetative shoots after anthesis are erect in *C.*

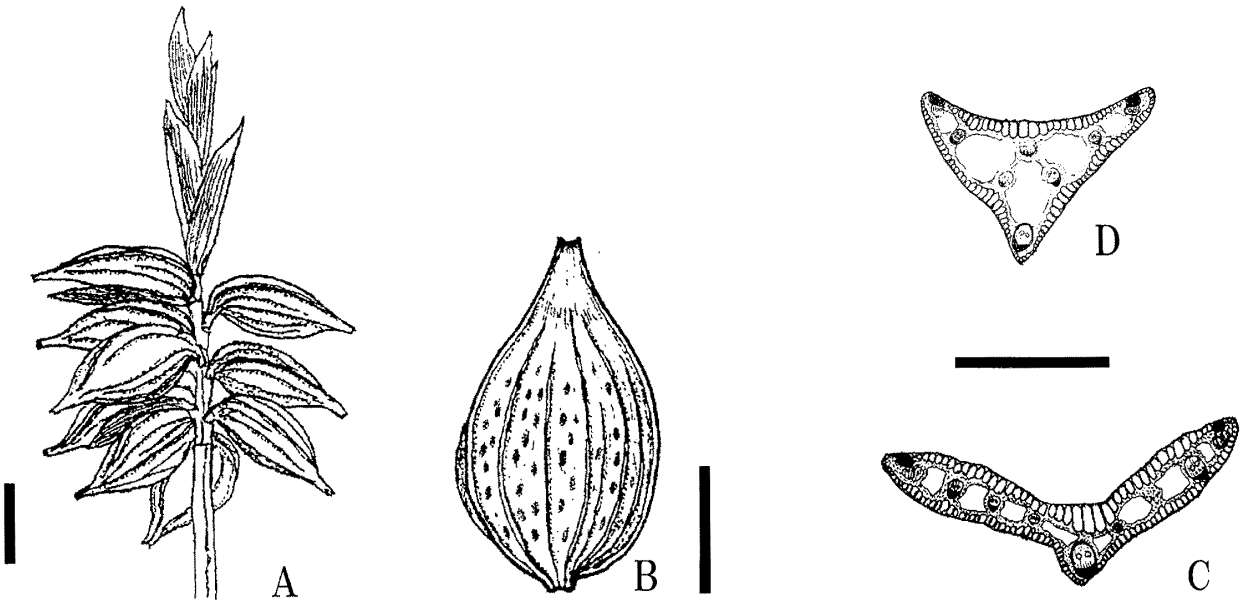

FIG. 3. *Carex capillacea* Boott. A: inflorescence. B: perigynium, adaxial view. C: outer leaf, cross section. D: inner leaf, cross section. bar = 1 mm for A & B; 0.5 mm for C & D. [Ryogaike, Daian-cho, Inabe-gun, Mie Pref., *J. Oda 587* (KYO)]

capillacea (Fig. 4B), while they are recurved in *C. koyaensis* (Fig. 4A). The leaves of *C. koyaensis* are softer than those of *C. capillacea*, supposedly because the former has fewer girders in the mesophyll (Figs. 2C–D and 3C–D).

Pistillate flowers

As shown in Table 1, in *Carex capillacea*, 11 individuals have perigynia with glandular dots but 2 specimens from Kuzakai and Nepal lack glandular dots. The specimens from Kuzakai and Nepal are doubtless referable to *C. capillacea* because of the v-shaped or triquetrous leaves, many flowers and achenes with cellulose anticlinal walls (be discussed below). The perigynia of *C. capillacea* do not always have glandular dots (Fig. 3B), although Boott (1858) described the perigynia of *C. capillacea* as 'with resinous dots.' Glandular dots have not been found on the perigynia of *C. ruralis* and *C. koyaensis*.

Carex capillacea has (6–) 8–13 (–15) pistillate flowers; *C. ruralis* and *C. koyaensis* have 4–6 (–8) (Figs. 1F–G, 2E–F, 3A, Table 1). This characteristic is useful for distinguishing the latter two species from *C. capillacea* in the field.

Achene micromorphology

Micromorphology of the achene epidermis is a taxonomically useful character at the sectional and specific rank in *Carex* (Toivonen & Timonen 1976, Hoshino 1984, Wujek & Menapace 1988, Rettig 1990, Dan & Hoshino 1994, Olgun & Beyazoglu 1997, Starr & Ford 2001, Oda et al. 2003). The silica bodies of the achene epidermis in *Carex capil-*

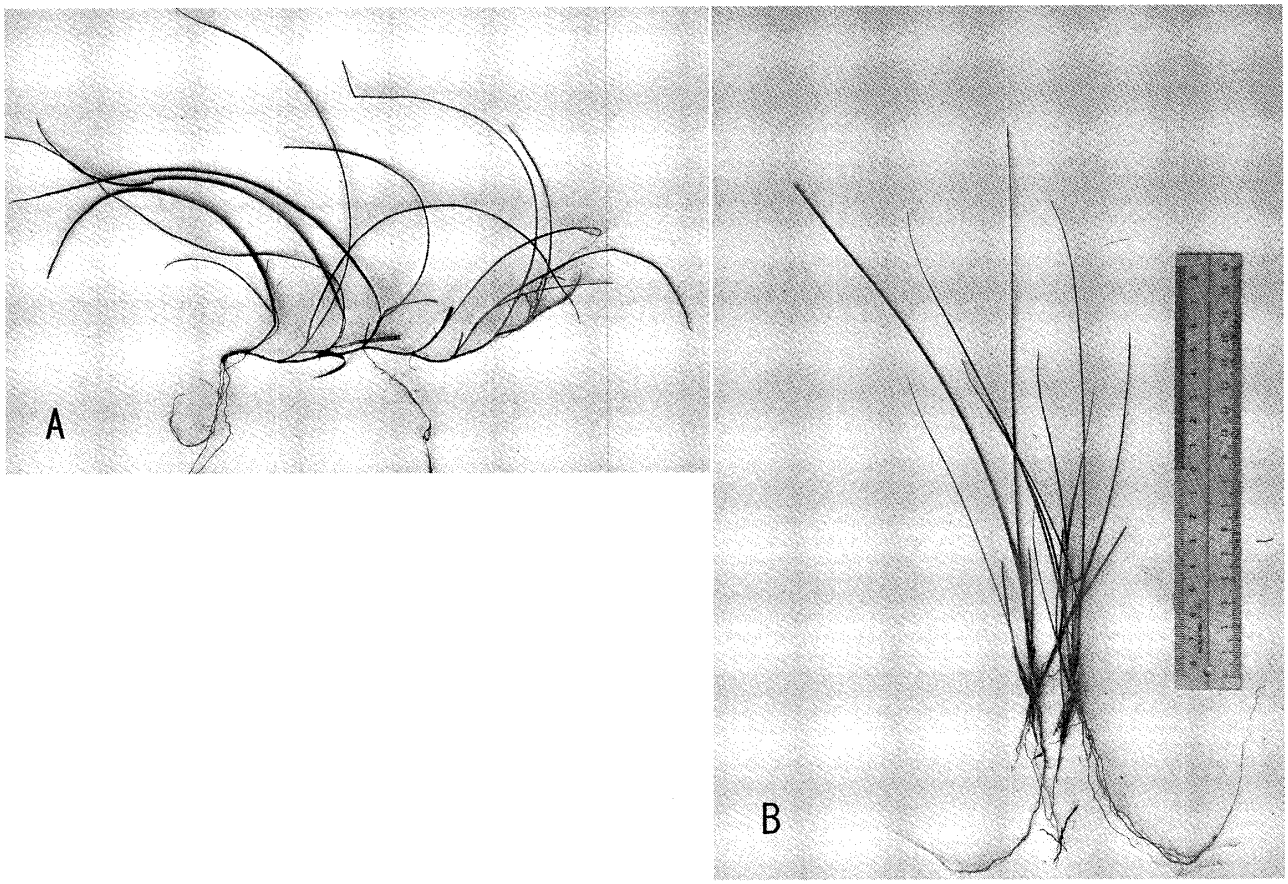

FIG. 4. A: *Carex koyaensis*, with long creeping rhizomes and recurved leaves. [Mt. Koya-san, Wakayama Pref., *J. Oda & S. Yamamoto 1639* (KYO), cultivated]. B: *Carex capillacea*, with abbreviated rhizomes and erect leaves. [Ryogaike-pond, Mie Pref. *J. Oda 587* (KYO), cultivated]

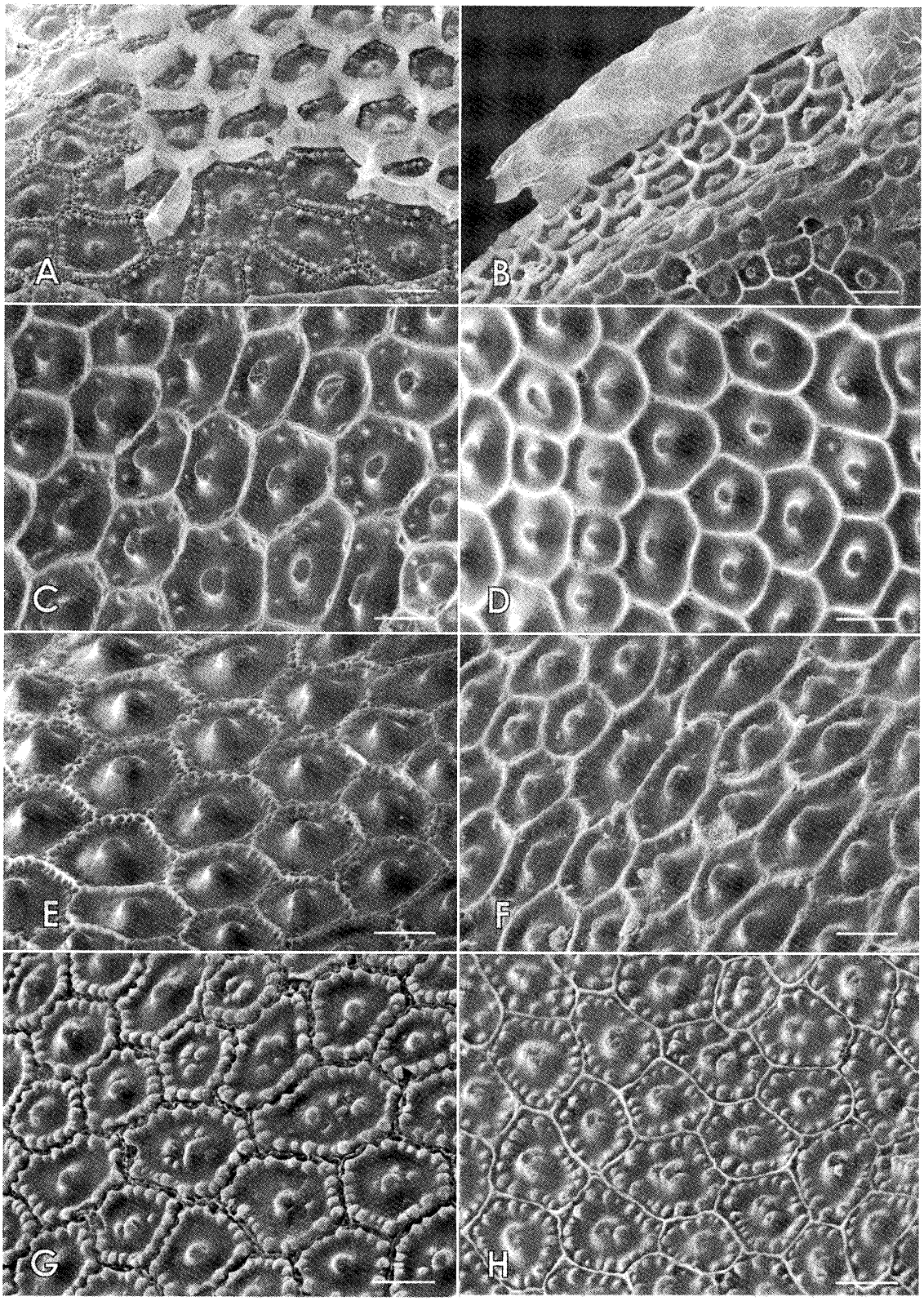

FIG. 5. Achene epidermis micromorphology. A: *Carex capillacea*, Ebinokogen, *Tak. Shimizu 86257* (KYO). B: *C. ruralis*, Nakatsugawa-shi, *S. Tsugaru et al. 27714* (KYO). C: *C. ruralis*, Mt. Tanokami-yama, *J. Oda & A. Tominaga 1300* (KYO). D: *C. ruralis*, Nenoue-kogen, Nakatsugawa-shi, *J. Oda 1561* (KYO). E: *C. koyaensis*, Mt. Gozaisho-dake, *J. Oda 1657* (KYO). F: *C. koyaensis*, Mt. Koya-san, Wakayama Pref., *J. Oda & S. Yamamoto 1639* (KYO). G: *C. capillacea* var. *capillacea*, Nepal, *N. Kurosaki et al. 8820449* (SHO). H: *C. capillacea* var. *sachalinensis*, Utonai, Hokkaido, *Tak. Shimizu 83479* (KYO). A and B: Epidermis with persistent cellulose cell walls after 3 hr soaking in acetolysis solution. C, D, E, F, G, H: Epidermis after cellulose cell walls removed by 6–10 hr soaking in acetolysis solution. Bar = 20 μm.

lacea , *C. ruralis* and *C. koyaensis* are rather diverse (Fig. 5, Table 1).

The silica platform of the achene epidermis is concave and the edges are thickened in all three species. The anticlinal walls of *C. capillacea* are not fully covered with silica deposits, so parts of the cellulose anticlinal wall are observed after soaking for three hours in the acetolysis solution. This feature was stable not only in specimens from Japan, but also in those from Nepal and Mt. Kinabalu, Malaysia (Fig. 5A, Table 1). The anticlinal walls of *C. ruralis* and *C. koyaensis* are fully covered with silica deposits so that the cellulose anticlinal walls are not visible and only the outer periclinal walls were removed (Fig. 5B, Table 1). The cellulose anticlinal walls exserted from the silica deposit were 7–15 μm long and the apex of the central bodies were not in contact with the outer periclinal wall in *C. capillacea*; the central bodies were all in contact with the outer periclinal walls in *C. ruralis* and *C. koyaensis*.

Carex capillacea had one to several central bodies whose apices were usually truncate, sometimes rounded, and 13–20 well-developed satellite bodies were regularly arranged along the anticlinal walls on the concave platform (Fig. 5G–H, Table 1). In *C. ruralis* (Fig. 5C–D) and *C. koyaensis* (Fig. 5E–F), however, the central body was solitary and well developed with a truncate apex; the satellite bodies were not as well developed on the concave platform as in *C. capillacea*. It may be only local variation in the two specimens of *C. ruralis* from Mie Prefecture, *T. Tsutsui s.n.* and *K. Yamawaki s.n.* that deviated by having as many satellite bodies as in *C. capillacea* (Table 1).

The anticlinal walls of *C. capillacea* and *C.*

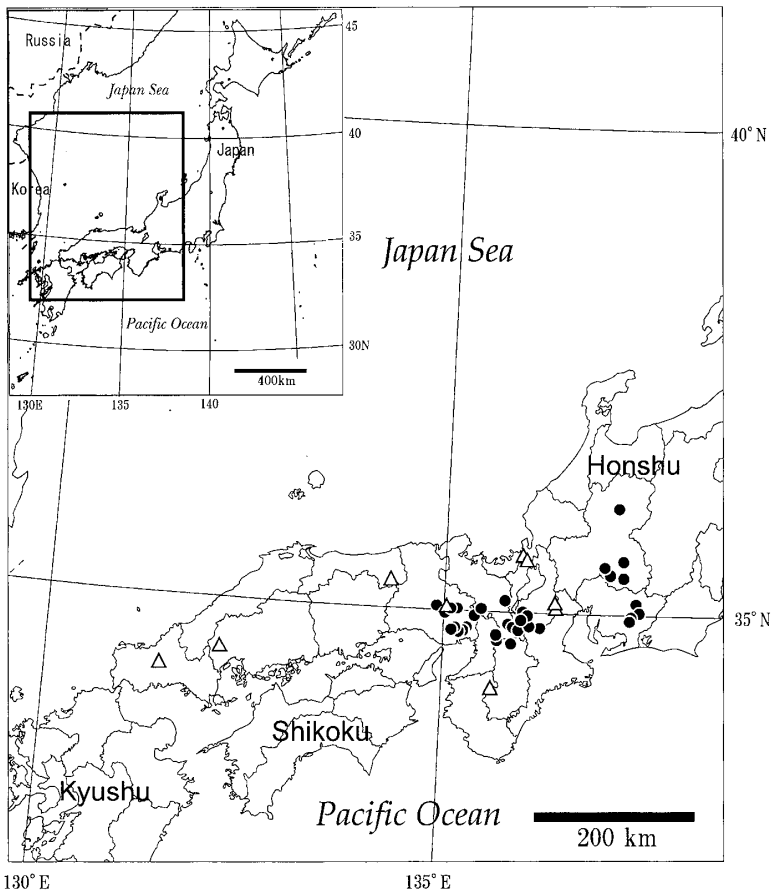

FIG. 6. Distribution map of *Carex ruralis* (disk) and *C. koyaensis* (triangle).

ruralis were slightly undulate, but those of *C. koyaensis* were honeycombed or slightly undulate to undulate. The honeycombed structure of *C. koyaensis* is sometimes hidden by the copious deposits of silica leaving undulate lines at the base of the of anticlinal walls, as in *J. Oda & S. Yamamoto 1639* from Koya-san, Wakayama Prefecture (Fig. 5D), and in *T. Sato s.n.* from Ohno-cho, Hiroshima Prefecture (Table 1).

Habitat

The species of *Carex* sect. *Capitellatae* all grow in wet places, such as the edges of wet forests, the sides of water, and sphagnum marshes (Akiyama 1955). In Japan, *Carex capillacea* var. *capillacea* mainly occurs in various habitat in the cool temperate zone (so called Fagus zone), while *C. koyaensis* mainly grows on streamlets in forests in the transitional zone between warm temperate and cool temperate zones. *Carex ruralis* prefers small sphagnum marshes in the warm temperate zone and is often associated with *Pinus densiflora*. Its range overlaps the range of *Symplocos paniculata* (Nagamasu 1993). Both *C. capillacea* and *C. ruralis* were found sympatrically in a sphagnum marsh at Nenoue-kogen, Gifu Prefecture (alt. 870 m), thereby providing evidence that *C. capillacea* and *C. ruralis* are distinct species and not intraspecific variants.

A key to the Japanese species of *Carex* sect. *Capitellatae*

1. Perigynia narrowly ovoid to lanceolate ..... *C. uda* Maxim.
1. Perigynia ovoid to widely ovoid
 2. Culms triangular to triquetrous, scabrous.
  3. Nerves on perigynia distinct ..... *C. fulta* Franch.
  3. Nerves on perigynia obscure
   4. Leaves 2–3 mm wide; achenes loosely enclosed by perigynium ..... *C. semihyalofructa* Tak. Shimizu
   4. Leaves 0.7–2 mm wide; achenes tightly enclosed by perigynium.
    5. Leaves 1–2 mm wide; apex of pistillate scales acute to acuminate; perigynia opaque; nerves on adaxial surface of perigynia 10–15 ..... *C. onoei* Franch. & Sav.
    5. Leaves 0.7–1.2 mm wide; apex of pistillate scales obtuse to acute; perigynia translucent; nerves on adaxial surface of perigynia 2–5 ..... *C. hakonensis* Franch. & Sav.
 2. Culms irregularly trigonous to tetragonous, smooth
  6. Rhizome long creeping; leaves soft, recurved; nerves on adaxial surface of perigynia 5–7, inconspicuous ..... **C. koyaensis** J. Oda & Nagam.
  6. Rhizomes abbreviated; leaves rigid, erect; nerves on adaxial surface of perigynia 6–10, conspicuous.
   7. Pistillate flowers 15–25; perigynia 1.6–2 mm long ..... *C. biwensis* Franch.
   7. Pistillate flowers 4–15; perigynia 2–4 mm long
    8. Leaves 0.5–0.8 mm wide; pistillate flowers 4–8; perigynia without glandular dots; mouth of beak usually light brown ..... **C. ruralis** J. Oda & Nagam.
    8. Leaves (0.8)1–2(2.3) mm wide; pistillate flowers 6–15; perigynia usually with glandular dots; mouth of beak rusty brown
     9. Perigynia 2–3 mm long ..... *C. capillacea* Boott var. *capillacea*
     9. Perigynia 3–4 mm long ..... *C. capillacea* var. *sachalinensis* (F. Schmidt) Ohwi

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